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BE (4th Semester)

Examination, Nov-Dec 2021

Branch : Mechanical

APPLIED THERMODYNAMICS

Time Allowed : Three Hours

Maximum Marks : 80

Minimum Pass Marks : 28

Note : Attempt all questions. Question carry equal marks. Part (a) is compulsory, attempt any two parts from (b), (c) and (d).

Q. 1. (a) An inventor claims to have developed a refrigerator that maintains the refrigerated space at 2°C, while operating in a room where temperature is 25°C & has COP of 13.5. Is this claim reasonable ? 2

(b) A heat source at 800 K losses 2000 kJ of heat to a sink at (i) 500 K & (ii) 750 K. Determine which heat transfer process that is more irreversible. 7

(c) Prove mixing of two fluids is an irreversible process. 7

(d) Helium enters a turbine at 300 kPa, 200°C expands to 100 kPa, 150°C; C_p = 5.2 kJ/kg K, molecular weight = 4.003. Calculate the change in availability. The atmospheric conditions are 1.013 kPa & 25°C. 7

Q. 2. (a) Define coefficient of volume expansion & coefficient of isothermal compressibility. 2

(b) Using thermodynamic relation prove Mayer's relation 7

$$C_p - C_v = \frac{T\beta^2 v}{K} = R$$

(c) Explain : 7

(i) Compressibility factor

(ii) Reduced properties

(iii) Compressibility chart

(d) The gas neon has a molecular wt of 20.183 and its critical temperature, pressure and volume are 44.5 K; 2.73 MPa; & .0416 m^3/kg mol. Reading from a compressibility chart for a reduced pressure of 2 and a reduced temperature of 1.3, the compressibility factor

Z is 0.7. What are the corresponding sp. vol., pressure, temperature and reduced volume.

From Comp. Chart at $p_r = 2$ & $T_r = 1.3$; $Z = 0.7$. 7

Q. 3. (a) What is the difference between compressed liquid & saturated liquid ? 2

(b) A rigid tank contains 10 kg of water at 90°C. If 8 kg of water is in liquid form and the rest is in vapour form, determine (i) the pressure in the tank (ii) the volume of the tank. 7

(c) Steam power plant operating on ideal Rankine cycle. Steam enters the turbine at 3 MPa and 350°C and is condensed in the

condenser at a pressure of 10 kPa (i) determine thermal efficiency of the plant (ii) thermal efficiency if steam is superheated to 600°C instead of 350°C, and (iii) the thermal efficiency if boiler pressure is raised to 15 MPa, while turbine inlet temperature is maintained at 600°C. 7

(d) Define vacuum efficiency of condenser. If vacuum maintained in a surface condenser is 700 mm of Hg and the barometer reads 760 mm of Hg. The temperature of condensate is 18°C. Find (i) partial pressure of air (ii) mass of air per kg of steam (iii) vacuum efficiency. 7

Q. 4. (a) Define Refrigeration. How dry ice is used for purpose of refrigeration. 2

(b) Explain vapour compression cycle with the help of sketch & T-s diagram. 7

(c) Why compressors are made multistage ? Determine equation of work of two stage air compressors with complete intercooling. 7

(d) A double acting single cylinder reciprocating air compressor has a piston displacement of .015 m^3/rev. operates at 500 rpm & has a 5% clearance. The air is received at 1 bar & delivered at 6 bar. The $comp^n$ & exp^n are polytropic with n = 1.3. Find volumetric η, power required, heat transfered & its direction during $comp^n$ of air at inlet temperature of 20°C. 7

Q. 5. (a) Define stagnation state & stagnation properties. **2**

(b) What is choking in nozzle flow ? Explain. **7**

(c) Prove for one dimensional steady isentropic flow **7**

$$\frac{dA}{A} = \left(M^2 - 1\right)\frac{dv}{V}$$

(d) An aircraft flies at a velocity of 700 km/hr in an atmosphere where the pressure is 75 kPa & temperature is 5°C. Calculate Mach number & stagnation properties. **7**